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MECHANISM AND VITALISM.

IF science had only living things as objects of study, beyond doubt it would now present itself under a very different aspect from that which it has received from the study of the non-living. Fundamental and all-inclusive doctrines, such as radical mechanism, have sprung historically from physical science, not from biology. Biological science is in but an embryonic condition as compared even with physical science. Would full analysis of the phenomena presented by the living yield a body of doctrine of the same kind that the study of the non-living gives us? In what respects would a science based primarily on the living differ from that based on the non-living? Would the final elements reached by analysis be the same in the two cases? Would the laws of change be the same?

The relatively incomplete formulations given by biological science would yield, taken by themselves, only fragments of the various kinds of scientific description set forth as existent in the formulation adopted as a basis of reference in this discussion.¹ Therefore, our examination of the questions just proposed will center chiefly about the underlying relations in the perceptual phenomena which make scientific formulation possible.

The fundamental characteristics of phenomena that in the non-living have given rise to the existing formulations of science appear to be as follows:

1. When studied by the method of experimentation (including inference from the results of experiment, with further experimental test of these inferences), the phenomena have shown such continuities in space and time that diversities in any given characteristic (save those of space and time) are accompanied by diversities in other characteristics. Thus alteration of one characteristic changes others, as when according to the law of gravi-

¹ R. F. A. Hoernlé, "American Philosophical Association; Preliminary Meeting of Leaders of the Discussion on Mechanism versus Vitalism." *J. of Ph., Psy. and Sci. Meth.*, XV, pp. 458-467 (see also pages 672, 673 of this number of the **REVIEW**).

tation, altering the distance between two bodies likewise alters the attraction between them.

Practically important is the temporal manifestation of these interconnections, in that later perceptual diversities in a system are always preceded by earlier perceptual diversities, which are found experimentally to determine the later ones (in the sense that if the earlier diversities are removed, the later ones disappear). The prevalence of this condition of affairs we call experimental determinism. We may sum up in the statement that *the formulation of inorganic science is a result of the prevalence throughout it of experimental determinism.*

2. The number of *effective* diversities is smaller than the number of separate phenomena distinguishable in space and time, so that there are common features in the distinguishable phenomena, and common results from the common features.

3. The determining diversities and their experimental consequences fall into an orderly system. Types of such partial systems are the three laws of motion; or within these, the laws of the parallelogram of forces. The entire orderly system resulting from experimental determinism constitutes inorganic science.

Does the science of the living show these characteristics? And to what extent is the system it yields like, or diverse from, that of inorganic science?

The various answers proposed for these questions are the theories of vitalism and of mechanism. Many diverse doctrines are held as vitalism, with a correlative number of opposed doctrines often designated as mechanism. Some of these doctrines relate to the general characteristics that have made scientific formulation possible; others to the contents of the formulated science. The diverse vitalistic theories may be grouped in three classes. One class criticizes the adequacy of experimental formulation for the phenomena of life. A second, accepting such formulation, maintains that when applied to the living it yields elements and laws diverse from those reached by the study of the non-living. The third class holds that life reveals the characteristics of the universe more directly than does the non-living, so that biology is more fundamental than physics.

We shall take up in succession these three classes of theories, asking: What would be the experimental situation if the given doctrine were correct?

I. DOCTRINES THAT CRITICIZE THE ADEQUACY OF EXPERIMENTAL FORMULATION FOR THE PHENOMENA OF LIFE.

Many vitalistic theories hold that the perceptual determiners of events,—those discoverable experimentally—are not ‘adequate’ to the results produced, at least in living things; that they cannot ‘account for’ what happens; they do not make it intelligible that the observed phenomena should appear.

It is clearly true that the experimental results produced under many perceptual conditions are to be learned in the first instance only by experience, and are not to be deduced from a previous analytical consideration of those perceptual conditions alone; in this sense the perceptual conditions are not adequate and do not make the results intelligible. Thus Neal argues that “the formula of mechanism” (which he identifies with experimental determinism) is not “adequate to experience.”¹ That this is correct in the sense just set forth is I believe generally recognized.

What follows from this? Three different sets of attitudes are taken by diverse thinkers. (1) One set admits that ultimate intelligibility in the sense of the deducibility of all occurrences from something else is not found. The final elements of knowledge—the phenomena and the interconnections of phenomena—are simply observed, not deduced nor ‘understood’; their number and nature can be learned only by experience. Intelligibility arises from the observed fact that the interconnections of phenomena, the correspondence of diversities, fall into an orderly system. To seek it anterior to or independent of these orderly interconnections is to seek it outside of that which constitutes it. This is equally true in the living and in the non-living. The work of science is merely to discover the elements and to formulate their interconnections.

A second attitude holds that since the perceptual conditions

¹ H. V. Neal, “The Basis of Individuality in Organisms; A Defense of Vitalism,” *Science*, XLIV, pp. 82-97.

do not give an adequate account of the resulting phenomena, it is necessary to assume in addition some non-perceptual agent which does. So, Neal maintains that "individuality (personality) is a phenomenon not determined by the perceptual conditions only, but requiring to account for it the agency of a non-perceptual agent."¹

Assuming the legitimacy of the demand for this type of intelligibility, the logical conclusion appears to be that the non-perceptual agent occurs *in addition to* the perceptual conditions; there seems here no ground for rejecting the experimental determiners, but only for supplementing them. This attitude is taken more or less vaguely by many. The perceptual things, the things that we see, it is held, are merely the garments of something non-perceptual; they are only signs by which are revealed the spiritual; they "weave God the garment thou seest him by." But these spiritual agents never act without a clothing of the perceptual, by which they may be detected. Thus we can use the perceptual in all our scientific work; it never fails to reveal to us the presence of the underlying spiritual realities.

It is obvious that such a doctrine leaves quite untouched that experimental determinism on which scientific formulation depends. The most convinced experimentalist can hold it without the slightest weakening of confidence in his methods of work. One finds in scientific literature little expression of such views, because obviously the matter has nothing to do with science; but conversation shows that there are many men of science that hold, in a more or less indefinite way, doctrines of this character. It is, I believe, under a hazy impression that the doctrines of Driesch are of this sort that many incline toward such a concept as entelechy. A thinker of high standing informs me that, although he rejects the experimental indeterminism of Driesch, he inclines to accept the remainder of the doctrine of entelechy; this may be typical.

Whatever the satisfaction such beliefs give to other instincts, they obviously do not satisfy that need which leads to the scientific analysis of complex phenomena. This need is based on the

¹ *Ibid*

complexities; transferring these to a non-perceptual agent, as Driesch transfers the complexities of development to entelechy, leaves them in exactly the same need of analysis and explanation as before. Such doctrines therefore can play no part in the work of science.

The third attitude toward the inadequacy of experimental formulation is the result of this scientific impotency of the non-perceptual agent conceived merely as added to the perceptual determiner; such ineffectual ghosts do not attract serious interest. This third view makes the non-perceptual agent play a really differential part; makes it take the place of missing perceptual determiners. It holds that from the same perceptual conditions in different instances diverse perceptual results may flow, depending upon the differential activity of non-perceptual agents, so that the experimenter is bound to find situations in which no perceptual determiners exist for perceptual diversities of result. It rejects experimental determinism (although it may cling to 'absolute determinism,' since the non-perceptual agent is held to determine the result).

I find reluctance on the part of some men of science to believe that there exist doctrines that are confessedly of this character. Yet the doctrines of vitalism that are now most influential are of precisely this kind; the non-perceptual agent must play a part that affects scientific formulation or men of science give it no attention. The vitalism of Driesch, doubtless that most discussed (though in its essence little known), is consciously of this third type; a full grasp of his complex system will show clearly that it is based on experimental indeterminism. As doubt has been expressed of this, it may be best not to leave the assertion to a sustained study which few will make. The question was put squarely to Driesch by both parties to a dispute on the matter, and as squarely answered. Driesch says: "I reject absolute indeterminism, but *accept* experimental indeterminism. . . . Two systems absolutely identical in every physico-chemical respect may behave differently under absolutely identical conditions, in case that the systems are living systems."¹

¹ See fuller quotations and discussion of this matter in the following papers: H. S. Jennings, "Driesch's Vitalism and Experimental Indeterminism," *Science*,

Many writers have expressed sympathy with the doctrine of Driesch, though whether they realize it to mean experimental indeterminism is not always clear. But Johnstone¹ presents the same sort of theory, consciously following Driesch. Neal² defends the same point of view, explicitly including the experimental indeterminism. Bergson³ as is well known, expressly holds to indeterminism in the living.

The commoner forms of vitalism indeed, though often but vaguely worked out, will be found to assume the production by a single agent of various diverse activities. The favored procedure is the selection, among various courses of action assumed to be possible under given perceptual conditions, of sometimes one course, sometimes another, depending upon the end to be reached. This is of course precisely experimental indeterminism, ineffectually concealed by the common practice of calling this agent by the conciliatory name of 'vital force.'

This type of vitalism has direct bearing upon scientific work; if perceptual determiners for diversities of occurrence do not exist, it is idle to search for them. To the extent that this doctrine is correct the experimental method fails in biology. I therefore propose to examine certain points as to the foundation for this doctrine, referring to my previous papers for discussion of others.

This type of vitalism (as indeed most others) is based mainly on those relations between phenomena that are characterized as teleological; upon adaptive activities and structures.

It must be questioned whether the teleological represents anything diverse in principle from what is given in ordinary scientific descriptions even of the inorganic; whether teleological description is anything more than a 'short-cut' for expressing in brief what could be expressed with equal accuracy in terms XXXVI, pp. 434, 435; "Doctrines held as Vitalism," *American Naturalist*, XLVII, pp. 385-417; A. O. Lovejoy, "The Meaning of Driesch and the Meaning of Vitalism," *Science*, XXXVI, pp. 672-675; see also H. Driesch, "Ueber die Bestimmtheit und Voraussagbarkeit des Naturwerdens," *Logos*, IV, pp. 62-84.

¹ J. Johnstone, *The Philosophy of Biology*, Cambridge, 1914.

² H. V. Neal, "The Basis of Individuality in Organisms; A Defense of Vitalism," *Science*, XLIV, pp. 82-97.

³ H. Bergson, *Creative Evolution*, New York, 1911.

that would not suggest purpose, but would require more words (and this because language has been built up largely on the basis of human purpose). Among the matters to be described and accounted for are the relative *durabilities* of phenomena. In an investigation of such matters, one would inquire how it happens that a piece of granite is more lasting than a piece of ice; how it happens that certain products of chemical reaction are evanescent while others endure; how it happens that some whirlpools last while others quickly vanish; that some river systems endure while others have disappeared; how it happens that certain processes (*e. g.*, the disintegration of radium) continue, while others are interrupted,—and so would pass without any logical break to the study of how it happens that the systems called living persist as they do (while many of them do *not* persist). In all cases one would find relations between the parts of the systems, on which the durability depends. In the more complex systems (rivers, solar systems, organisms) one would find relations between complex components tending to the maintenance of the system or of its component phenomena. To apply the same terms to these relations that we apply to the conscious purposes of human beings is justifiable only on the ground that these conscious purposes likewise tend to the maintenance of certain phenomena; but it should be done equally for those characteristics of the inorganic that show similar relations, as has recently been done on a large scale by Henderson.¹

Organisms are complex cyclical systems, a similar train of successive phenomena being repeated in each cycle that constitutes the total life of an individual. In such systems adaptive relations show themselves between phenomena separated in time, and *if we limit consideration to a single cycle* or individual life, as is commonly done, an earlier phenomenon shows evident

¹ L. J. Henderson, *The Fitness of the Environment*, New York, 1913. The conception of the teleological as a matter of durability has been developed by many, notably by W. Roux, (*Der Kampf der Theile im Organismus*, Leipzig, 1881) who was perhaps the first to so interpret it; by P. Jensen (*Organische Zweckmässigkeit, Entwicklung und Vererbung vom Standpunkte der Physiologie*, Jena, 1907); and recently in a valuable paper by R. Lillie ("What is Purposive and Intelligent Behavior from the Physiological Point of View", *J. of Ph., Psy., and Sci. Meth.*, XII, pp. 589-610) who deals with it as the maintenance of equilibrium.

relations to one not appearing till later in that particular cycle, as when the lens of the eye develops in the dark. It is mainly these relations to the future that have raised the problem of teleology.

This problem does not arise from the nature of the single acts involved in adaptive processes; it will be admitted that each of these taken by itself would present no obstacles to perceptual determinism. If shots are made in all directions, some will go toward a particular mark; for those that do so no special explanation, no effect of the mark on the direction of the shots, is required. It is only when the others are omitted and all go toward the mark that the question arises whether the mark is influencing the direction of the shots. Eyes do not now develop in every conceivable way, only one in ten million producing a structure resembling a lens; if this were true, no one would feel that this single case required a teleological explanation. The problem of teleology in complex systems is based on a statistical situation; certain operations tend more uniformly toward a particular mark than appears to be accounted for by determination independent of the mark; and when the 'mark' does not exist (*in the particular cycle under consideration*) until later, the problem takes on its most characteristic form.

Does such a situation exclude experimental determinism? On the contrary, a general method is known by which experimental determinism results in this situation; the knowledge is now a common possession of mankind. It is the method of automatic persistence of one type of activities, or of one configuration, out of many produced or begun. The method is exemplified throughout nature; particularly in physical chemistry, with its study of equilibria and of rates of reaction. In living things it is known that such action takes place on a grand scale. In an extremely gross form we are familiar with it as natural selection. In another we see it, as the formation of habits, producing adaptive actions within the compass of a single individual cycle; out of movements that are at first varied, some become fixed.

In sum, we find throughout nature a method fully intelligible

as perceptually determined in every step, by which a set of acts becomes directed toward an end. The occurrence of such adaptive action is therefore not evidence against perceptual determinism, but results precisely from its operation.

Turning to certain concrete fields, the case for the vitalism that rejects experimental determinism rests largely upon arguments from the development of organisms, as elaborated by Driesch. I believe that it may be correctly said that the advance of knowledge in this field has destroyed the factual basis of Driesch's argument. In an earlier paper¹ I attempted to summarize these advances in their bearing on the problems now under discussion. Space does not permit setting forth the concrete facts here, but certain general relations may be touched upon. Driesch's argument is based fundamentally upon the development and regeneration of what he calls "harmonic equipotential systems"; the eggs and bodies of many organisms are characterized as such. The basis for this concept is the fact that various parts of the egg or organism can produce an entire organism, or other parts than those which they usually produce. Hence it is concluded that all the elements of the developing organism are potentially the same; that any part can produce any part ("*Jedes kann jedes*") that the fate of a part depends upon its position; that the system is "*equipotential*." From this it is argued that development cannot be determined by any "typical configuration of physical and chemical elements," such as might be called a machine, although perceptually it could not be determined in any other way. It follows therefore that it is not perceptually determined; a non-perceptual determiner—entelechy—must be called in to account for the results.

From this line of argument it might readily be supposed that all parts of such germs are actually potentially equivalent, in the sense that one could be substituted for the other. This would amount to a complete lack of *effectively* diverse parts in the germ, leaving indeed the problem of the method of development into the complex animal in a desperate situation. Such a

¹ "Development and Inheritance in Relation to the Constitution of the Germ," *Johns Hopkins University Circular*, December, 1914, pp. 21-72.

conclusion has indeed been drawn even by men expert in biology; von Uexküll for example asserts that "Driesch succeeded in proving that the germ cell does not possess a trace of machine-like structure," and that "the organization of a structureless germ into a complicated structure is a power *sui generis*," etc.¹

It appears probable that such a notion is widespread among men not familiar with the facts at first hand.

As a matter of fact, *no such thing as an equipotential system exists* among organisms, if the phrase be taken in any literal sense. Driesch himself remarks that it is only "an approximate, as it were, figurative, method of speech."² The "elements" of the germ which are asserted to be potentially alike are in fact each complex systems, in which the parts are by no means effectively or potentially equivalent. Each such "element" contains a visible complex apparatus, known as the chromosomal apparatus. The recent study of genetics has shown that this apparatus is the system on which the peculiarities of development mainly depend. This system is not equipotential; the fate of its parts is not a function of their position; it has a complex structure with a corresponding complexity of action; altering any of its parts alters correspondingly the action of the system; irregular removal or disarrangement of the parts destroys the action. This apparatus visibly interacts throughout development with the less differentiated cytoplasm, visibly producing developmental differentiations. Nothing could be conceived that would furnish a better basis for an experimentally determined and experimentally intelligible course of development.

Now, organisms are peculiar in that each small part of the body contains such an apparatus complete. No part of the body or germ that does not contain such a system will develop. But each part that does contain such a system is capable of developing into an entire body or into any part of the body,—*provided the proper other conditions are supplied*. But this proviso limits the realizable possibilities in a high degree. The nature of many of the necessary other conditions is slowly becoming known, and

¹ "Die Neuen Fragen in der Experimentellen Biologie," *Rivista di Scienza*, "Scientia," IV.

² *Naturbegriffe und Natururteile*, p. 181.

the whole furnishes the outline of a natural, experimentally intelligible scheme of operation.

It is extraordinary how precisely the distribution and operation of this apparatus fulfills the conditions set forth by Driesch as a basis for his assertion that no material system ("machine") can underlie development. After setting forth that a machine "might very well be the motive force of organogenesis in general, if only normal, that is to say, if only undisturbed development existed, and if a taking away of parts of our system led to fragmental development," he points out that "there may be a whole development out of each portion of the system, above certain limits, which is, say, of the Volume V. Good! Then there ought to exist a machine, like that which exists in the whole undisturbed system, in this portion V also, only of smaller dimensions; but it also *ought* to exist in the portion V_1 , which is equal to V in amount, and also in V_2 , in V_3 , V_4 and so on. Indeed, there do exist almost indefinitely many V_n , all of which can perform the whole morphogenesis, and all of which therefore *ought* to possess the machine. But these different portions V_n are only partially different from each other in spatial relation. Many parts of V_2 are also parts of V_1 and of V_3 and of V_4 and so on; that is to say, the different volumes V_n overlap each other successively and in such a manner that each following one exceeds the preceding one by a very small amount only. But what then about our machines? Each volume which may perform morphogenesis completely must possess the machine in its totality. As now every element of one volume may play any possible elemental rôle in every other, it follows that each part of the whole harmonious system possesses any possible elemental part of the machine equally well, all parts of the system being at the same time constituents of different machines. A very strange sort of machine indeed which is the same in all its parts." Driesch therefore concludes that "therefore there can be neither any sort of a machine nor any sort of causality based upon constellation underlying the differentiation of harmonious equipotential systems."¹

¹ The passages quoted are from Driesch, *The Science and Philosophy of the Organism*, Vol. I, 1908, pages 139-141. The discussion is elucidated by a diagram.

Now, if we call the chromatic apparatus the 'machine,' this passage might almost be considered a statement of the observed facts concerning its distribution and action. If the pieces are cut so as to contain one or more of the complete 'machines,' and the other necessary conditions are supplied, each will produce an entire organism. If a piece is left without a 'machine,' or with only an imperfect one, it will not develop.

How the 'machines' are activated and correlated; how development occurs, presents experimental problems in great number, but they are totally diverse in character from the riddle that an actually 'equipotential system' would put before us; they have no implications of experimental indeterminism.

After long standstill, in no field has knowledge of perceptual determination so increased in recent years as in that of development and inheritance; no field yields more full and minute testimony to the existence of perceptual determiners for all sorts of diversities of occurrence. No case can be cited in which perceptual diversities of result are without experimental determiners; in most cases it is easy even now to point these out. The picture of the phenomenal situation on which Driesch based his vitalism has in my opinion been completely superseded.

The condition of affairs just scheduled may be fairly said, I believe, to be typical for the progress of biological science. In chemical regulation and in behavior, which have likewise been exploited for the differential activity of a non-perceptual agent, knowledge is perhaps less adequate than in development. But continued investigation yields steady increase of knowledge of perceptual determination in both these fields. In behavior, the extraordinary complexity of the nervous system furnishes groundwork for a complete correspondence between antecedent perceptual conditions and later occurrences; and study of heredity and of environmental conditions in determining behavior adds evidence in the same direction. Nowhere does a bar to progress appear.

A special position with relation to this problem has often been given to the phenomena of 'conscious states,' which accompany behavior in some living things. On the existence and apparent

effectiveness of these are based the vitalistic doctrines known as psycho-vitalism. If, as may be urged with plausibility (though not demonstrated), these are peculiar to living things, then we have, *ipso facto*, a basis for a purely descriptive vitalism; something occurs in the living that does not occur in the non-living. Beyond this, the legitimate postulate of psycho-vitalism appears to be that diverse conscious states result in diverse actions. Experimental science, in my opinion, has no proper quarrel with this proposition. To the particular individual his 'conscious states' answer all tests for experimental determiners of his actions, and I see no ground for withholding from them this designation. The only ground on which this could be done would be the assumption that they are not, like other perceptual determiners, bound up with objective perceptual phenomena that act in turn as determiners of them. If diverse conscious states (for example, diverse purposes or diverse sensations) may occur and produce diverse actions when all other perceptual conditions are the same, then the 'conscious state' acts precisely as a non-perceptual determiner; and particularly does it play this rôle in the experimentation of an investigator who is not the particular self to whom these conscious states are proper. If the same organism with all objective perceptual conditions identical, may act sometimes in one way, sometimes in another, as determined by diversities of conscious state that are inaccessible to the experimenter, then in biology the investigator is indeed confronted with experimental indeterminism.

There is no experimental ground for the assumption that leads to this result. In all classes of 'conscious states' we know that diversities are experimentally producible by diversities in objective perceptual conditions. The farther investigation proceeds, the more extensive and precise becomes this correspondence. No case is established of a diversity in conscious states that is not experimentally determined by a diversity in objective perceptual conditions. To argue that such occurs is to employ ignorance as foundation for a positive doctrine. The assumed isolation of 'conscious states' is not based upon experimental analysis, but is opposed to it. Experimentally they bear to

other phenomena relations comparable to that between attraction and inertia (mass) as expressed by the law of gravitation; when one changes the other changes, so that each is a condition of the other. The experimental determination of other phenomena by diversities in conscious states, presents no difficulties to the investigator. Since with different conscious states (as with different inertias) there always go other diversities, to the outside investigator these other diversities serve as experimental determiners. That is, the diverse activities have as experimental conditions diverse antecedents both in 'conscious states' and in other phenomena, and the question as to which are the 'real' determiners has no experimental meaning. The situation does not differ from that presented by other phenomena, for the basis for experimentation lies in the fact that no one phenomenon changes without a change in another. It presents no foundation for the common gibe that those who accept it hold that all would occur exactly as it does without consciousness.¹ As well argue that all would occur as it does without gravitation or chemical action, or any other constituent phenomenon of the universe. The fact that these are bound up throughout with other perceptual conditions is no more an argument against their playing a part in the universe than it is against the effectiveness of consciousness. No experimental meaning can be given to the statement that the same conditions without consciousness would produce the same result; for the same conditions do not occur without consciousness.²

In all these most difficult fields, the history is one of steady progress in the discovery of experimental determiners, and this coupled with the fact that no cases are found which when fully examined lack experimental determiners, logically leads to the conclusion that there is no bar to the extension of this kind of knowledge in any direction and to any case whatever; that perceptual determiners will be found for any occurrence that is suffi-

¹ See Neal, "The Basis of Individuality in Organisms; a Defense of Vitalism"; *Science*, XLIV, pp. 82-97, for exploitation of this notion.

² This impotence of consciousness is a deduction, as will be brought out later, from the narrowest special doctrine of mechanism; thence it has been illegitimately transferred to experimental determinism by opponents of the latter.

ciently studied. The argument against experimental determinism is an argument from our ignorance; but an argument from ignorance is not strong when that ignorance decreases in proportion to the thoroughness of examination.

What is the bearing of the fact that the complex and variable phenomena which there is most tendency to ascribe to the operation of non-perceptual agents, or to consider quite undetermined, occur precisely in connection with the most complex, varied, and changeful perceptual conditions? If they occurred in connection with simple and uniform perceptual substrata, there might indeed be difficulty in supposing antecedent perceptual diversities for all diversities of occurrence. But the bewildering complexity and variety of occurrence in living things is fully met by a correspondingly bewildering complexity and variety of perceptual conditions; the latter set have no more been penetrated by the mind's eye than have the former. This complexity of perceptual conditions underlying the complex activities of life is inexplicable if diversities of action do not require diversities of perceptual conditions.¹ Moreover, the positive fact that the perceptual conditions underlying life are precisely such as would give rise to the sort of phenomena found in the living has been demonstrated at length by Henderson². To account for these things the upholder of non-perceptual determination is logically driven toward some such desperate assertion as that made in pre-evolutionary times to account for the occurrence of fossil remains; they exist in order to test the tenacity of faith of those who cling to determination by non-perceptual agents. To reject the inexhaustible store of perceptual determiners in order to assume non-perceptual ones is to sin against the law of parsimony; it creates entities without need.

¹ See the development of this point by R. S. Lillie, "The Philosophy of Biology; Vitalism versus Mechanism," *Science*, XL, pp. 840-846.

² *The Fitness of the Environment*.

II. DOCTRINES WHICH HOLD THAT SCIENTIFIC FORMULATION APPLIED TO THE LIVING YIELDS ELEMENTS AND LAWS DIVERSE FROM THOSE REACHED BY STUDY OF THE NON-LIVING.

We have tried to show that the progress of science tends to establish the experimental determinism of all phenomena, living as well as non-living. *Such experimental determinism is independent of all doctrines that would require the elementary phenomena and laws to be the same in the living as in the non-living; that hold it theoretically possible to deduce or predict the phenomena of the living from those of the non-living; that would deduce all knowledge from one or a few principles or analyze all phenomena into one or a few elements.* It does not imply or oppose the 'autonomy' of different classes of phenomena. All it demands is a systematic correspondence of later perceptual diversities with preceding ones; what the later diversities shall be, need not be known till they occur. So far as it is concerned, when conditions or configurations not before examined or not before occurring are studied, entirely new phenomena may appear; and these in their turn beget other new ones. It does not demand this, nor does it forbid this. It demands only that if a new phenomenon appears, it shall be the result of a new combination of conditions, not of one that has previously occurred.

Biological science at its present stage can do little to establish or refute, with probability, these special doctrines. The investigations hitherto made do not rule out the occurrence in the living of types of phenomena that do not occur in the non-living. Many phenomena have been set forth as peculiar to the living; the production of but a single one of the two sorts of asymmetrical crystals¹; the occurrence of objects combining "typical" form with changing physico-chemical constitution (Driesch); non-obedience to the second law of thermodynamics²; the occurrence of consciousness. Some of these are complex phenomena, the occurrence of which would not clearly involve new elements or

¹ See W. McPherson, "Asymmetric Syntheses and their Bearing on the Doctrine of Vitalism," *Science*, XLV, pp. 49-57; 76-81.

² H. Driesch, "Das Leben und der Zweite Energiesatz;" *Ann. d. Naturphilosophie*, VII, pp. 193-203.

laws. Others are uncertain as to their occurrence or distribution. The most plausible case for new elementary phenomena can be made out for consciousness, but it is not possible to prove that this is limited to the living; Haeckel for example holds it to occur throughout nature. In many cases these supposedly 'new' phenomena are set forth as indices of non-perceptual determining agents, but their occurrence appears to give no indication of experimental indeterminism. Nothing in the history of biological science negatives their occurrence in living things alone.

The most famous of the all-inclusive doctrines derived from inorganic science is mechanism (in the strict sense). A consideration of its relation to biology will best bring out the state of that science in respect to a number of disputed questions.

The essence of the doctrine of mechanism is something as follows: Many phenomena turn out on examination to be merely special cases of certain general relations between a restricted number of elements; general relations that are circumscribed and perspicuous, all following a single general law. For example, the resultant of two forces acting at an angle of thirty degrees may be examined, after resultants from other angles have been studied; the new case is found to be comprehended in the same law as the others. The relations of the elementary phenomena, —electrons, atoms, positions, motions, etc.,—appear to form a system of such limited variability as to be exhaustible by the mind. Distance alters in but two ways; mass in but two ways; angles of action only through the circumference of the circle; and so on, the possible relations being determinate in number and character. And so it appears to be possible to give a complete schema for all possible configurations and motions. All things in motion appear to find their precise places in this schema. To compute the future configurations and motions of any system it is required only to supply the quantitative data for any particular instant.

Mechanism in its more restricted form holds that all configurations and motions are thus determinate and computable. In a more inclusive form it may hold that all phenomena are nothing but such computable configurations and motions. In a

third and intermediate form it holds that any phenomena other than configurations and motions occur at specific and computable junctures of the configurations and motions, so that the laws of occurrence of all phenomena are statable in terms of those of configuration and motion.

What is the relation of biological science to this doctrine in its various forms?

At least some living things present the phenomena of 'conscious states.' There is practically complete agreement that these are not analyzable into 'nothing but' configurations and motions. Grant that they occur at certain configurations and motions, the 'conscious state' adds a distinctive element to these. If this be admitted, it is clear that mechanism in its more inclusive form is not correct for the living; they are not '*nothing but*' configuration and motion.

No one will deny that some conscious states are subject to experimental determination; a weight falling on the foot experimentally yields pain. Such instances show that *not all experimental determination is completely analyzable into the elements set forth by mechanism*; the *thing determined* at least is here something additional.

Does the lack of coincidence between experimental determination and mechanism go farther than this? May the next step in the process—the movement following the conscious state—likewise not coincide with that predictable from a mechanism that does not take into consideration the conscious state?

Here is the crux of the problem of mechanism. Are our actions and those of other living things computable from the system of mechanism, given a knowledge of the configurations and motions of the system preceding the occurrence of the state of consciousness?

Evidently if the schema of mechanism includes the nature of the motions under all possible configurations (which appears not theoretically difficult in consideration of the nature of the schema), then mechanism *can* theoretically predict just what I shall do, without consideration of the state of consciousness that occurs. This is the theoretical situation that results in making conscious-

ness a mere epiphenomenon. If actions can be computed and predicted without taking states of consciousness into consideration, then the latter are not differential determiners.

If on the other hand the conscious state is something that must be considered in the computation; if the computation carried out without it results in a false prediction; then at the occurrence of the conscious state the laws of motion of the particles must become altered. The electrons, the atoms, or other units, now move according to other laws,¹ and a diverse general result follows. If, for example, it is in the laws of composition and resolution of forces that the change comes, then the resultant of the various forces at work would be no longer computable from their number, dimensions, directions and relative angles of action according to the laws that prevailed before the state of consciousness occurred.

This would be strictly compatible with experimental determinism provided the configurations at which the different states of consciousness arose were diverse from those at which there was no consciousness; experimental determinism does not demand that the results of any particular configuration shall be known until it occurs. There is I believe nothing in the results of the investigation of the living that opposes this possibility.

To pursue the matter a step farther, if we assume mechanism for the non-conscious, and hold that the appearance of a particular 'conscious state' is subject to experimental determinism, then the origin of that state would have to result from a particular configuration and motion. After this had been discovered for a particular case, it could be predicted; it would be known that in that situation the laws of motion would change in such and such a way. Such discoveries could be continued indefinitely, for all sorts of states of consciousness. The result would at any time be a system of laws of motion comparable to that of classic mechanism, but infinitely more complex; it would be a mechanism that was always unfinished; at least until the study of all diverse states of consciousness was exhausted.

¹ See the various possibilities set forth by Pearson, *Grammar of Science*, 1911, Chapter IX.

According to the recent valuable review of Cohen,¹ strict mechanism (as nothing but configuration and motion) has not shown itself adequate to the formulation of physics. Certainly therefore it need not be accepted dogmatically for biology. Its claim to be a universal formula is not thus far supported by the science of the living.

III. DOCTRINES THAT THE UNIVERSE IS BIOCENTRIC.

A third class of vitalistic doctrines holds that the study of the living better reveals the essential nature of the universe than does the study of the non-living. It points out that the constitution of the universe is such that it produces life; the universe is adapted to that result (Henderson); it is of such a nature that conscious individuals arise in it. Hence it is argued that the nature of the universe would by no means be correctly discovered through a study of the non-living alone. Biology, it may hold, is as fundamental as physics, having its own original relation to reality; revealing what physics does not. All this, it appears to me, is thoroughly consistent with what we know of the living. The doctrine demands experimental determinism, and is based on the concrete results found to flow from it. Such doctrines may be carried farther, to argue that the production of conscious individuals is the central fact of the universe; that it is 'for' this that the universe exists, and the like. With such assertions the doctrine is carried outside the universe of discourse of science.

H. S. JENNINGS.

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¹ "Mechanism and Causality in Physics," *J. of Phil. Psy., and Sci. Meth.*, XV, pp. 365-386.